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# NAUTICAL PROPOSITIONS AND INSTITUTES; OR DIRECTIONS FOR THE PRACTICE OF NAVIGATION:

DRAWN,
From the AUTHOR's WRITINGS on this Subject,
and Arranged in a regular & methodical Order;
as they are to be learned, remembered and applied
for USE at SEA, &c.

BY

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# NAUTICAL PROPOSITIONS AND INSTITUTES, &c.

By S. DUNN.

## SECTION I.

### DIRECTIONS concerning the firſt Principles of Arithmetic.

1. NUMBERS are added together by the rule of Addition: They are ſubtracted by the rule of Subtraction. They are multiplied by the rule of Multiplication. They are divided by the rule of Diviſion.

2. Numbers are reduced to leſſer Denominations, when they are multiplied by as many of the leſſer Denomination as make one of the next greater.

3. Numbers are brought to greater Denominations, when they are divided by as many of the leſſer Denomination as make one of the next greater.

4. In Direct Proportion, the firſt and third Terms are of one name, and the ſecond Term of the ſame name as that which is ſought.

5. The Product of the ſecond and third Terms divided by the firſt Term, gives the fourth Term.

## SECTION II.

### DIRECTIONS concerning Decimals and other Fractions.

1. A Decimal is a Fraction whoſe Denominator is Unity with a Cypher or Cyphers following it.

2. All other Fractions are called Vulgar Fractions.

3. When the Numerator is leſs than the Denominator, it is a Proper Fraction; but when the numerator is greater than the denominator, it is an Improper Fraction.

4. Equal Fractions, have their Numerators in the ſame Ratio to each other as their Denominators.

5. Fractions having unequal Denominators, are to be reduced to equal ones, previous to Addition and Subtraction.

6. Fractions having equal Denominators, are added by adding together their Numerators, and ſubtracted by ſubtracting one Numerator from the other; retaining the Denominator unaltered.

7. Fractions are multiplied, when their Numerators are multiplied together for a new Numerator, and their Denominators multiplied together for a new Denominator.

8. Fractions are divided, when the Numerator of the Diviſor is multiplied into the Denominator of the Dividend for a Denominator of the Quotient; and the Denominator of the Diviſor multiplied into the Numerator of the Dividend for a Numerator of the Quotient.

9. Direct Proportionality in Fractions, is the ſame as in Whole Numbers.

## SECTION III.

## Directions concerning the Uſe of Logarithms.

1. The Index of a Logarithm, is leſs by Unity (or 1) than the number of figures of whole numbers in the natural number to which it belongs.

2. When a Natural Number is partly a Whole Number and partly a Decimal; the Logarithm without its index, is the ſame as it would be, if the Whole Number and Decimal together were a whole number, unſeparated by a point.

3. The Sum of the Logarithms, of two numbers, is the Logarithm of their Product.

4. The Difference of the Logarithms of two numbers, is the Logarithm of their Quotient.

5 In Direct Proportion; the ſum of the Logarithms of the ſecond and third Terms, leſſened by the Logarithm of the firſt Term, gives the Logarithm of the fourth Term.

6. Half the Logarithm of a number, is the Logarithm of its Square Root.

## SECTION IV.

## Directions for computing the Time of High Water at a given Place.

1ſt. Add 1 to the year of our Lord, and divide the ſum by 19, the remainder is the Golden Number.

2d. Subtract 1 from the Golden Number, multiply the remainder by 11 and divide the product by 30, the remainder is the Epact.

3d. The numbers for the months are as follows.

| | | | |
|---|---|---|---|
| January | 0. | July | 5. |
| February | 2. | Auguſt | 6. |
| March | 1. | September | 8. |
| April | 2. | October | 8. |
| May | 3. | November | 10. |
| June | 4. | December | 10. |

4th. Add together the Epact, the number for the Month, and the Day of the month; divide the ſum by 30, and the remainder is the Moon's age in days.

5th. Multiply that age by 4, and divide the product by 5, the quotient is the hour of the Moon's being on the Meridian that day.

6th. To that hour add the hours for the given place, as it is in the Tide Table, and the ſum is the hour of High Water at that place.

7th. The day begins at Noon, 12 hours later than according to the common account, and continues to 24 hours the next noon.

8th. The High Water happens at the end of a little leſs than 25 hours, likewiſe at the end of every 12 hours and half nearly.

## SECTION V.

### Directions concerning Plane Triangles.

1. Every circle contains 360 Degrees, and each Degree 60 Minutes.

2. A Plane Angle is the Inclination of two ſtraight lines to each other, and which meet at a Point.

3. A Plane Triangle hath three Angles, which together are equal to two Right Angles, or 180 Degrees.

4. In a Right-angled Plane Triangle; its two leſſer Angles together are equal to one Right Angle, or 90 Degrees.

5. The Sides of all Plane Triangles, are directly proportional to the Sines of their oppoſite Angles.

6. The Complement of an Angle, is its remainder to 90 degrees. The Supplement of an Angle, is its remainder to 180 Degrees.

7. In any Plane Triangle; As the Sum of two ſides is to their Difference, ſo is the Tangent of half the ſum of the oppoſite Angles, to the Tangent of half the difference of thoſe Angles.

8. Half the difference of two numbers added to their half ſum, gives the greater number; and ſubtracted from the half ſum gives the leſſer number.

9. An Oblique-angled Triangle hath its three ſides unequal. Its longeſt ſide is the Baſe, the other two ſides are called Sides. The Perpendicular falls on the Baſe from the Angle oppoſite thereto, forming the greater and leſſer Segment.

10. As the Baſe, is to the Sum of the ſides; ſo is the Difference of the ſides, to the Difference of the Segments of the baſe.

11. Half the Difference of the Segments added to Half the Baſe, gives the Greater Segment; and ſubtracted from Half the Baſe gives the Leſſer Segment.

12. When Angles are exceeding ſmall; their arches may be treated as the Sines of them, without ſenſible error.

## SECTION VI.

### DIRECTIONS concerning Right-angled Plane Triangles.

1. In a Right-angled Plane Triangle, the longeſt ſide is the Hypothenuſe, the ſhorteſt ſide the Perpendicular, and the other ſide the Baſe.

2. As the Baſe, is to the Perpendicular; ſo is the Radius, to the Tangent of the Angle at the Baſe.

3. As the Perpendicular, is to the Baſe; ſo is the Radius, to the Tangent of the Angle at the Perpendicular.

4. As the Sine of an Angle, is to its oppoſite Side; ſo is the Sine of another Angle of the ſame Triangle, to its oppoſite Side.

5. As a Side, is to the Sine of its oppoſite Angle; ſo is another Side of the ſame Triangle, to the Sine of its oppoſite Angle.

6. The Square of the Hypothenuſe, is equal to the Sum of the Squares of the Baſe and Perpendicular.

7. The Hypothenuſe may repreſent Radius, when the Baſe and Perpendicular repreſent Sine and Coſine.

8. The Baſe or Perpendicular may repreſent, one a Radius and the other a Tangent, when the Hypothenuſe repreſents a Secant.

9. The Things themſelves and what they repreſent, will be directly proportional.

## SECTION VII.

### DIRECTIONS concerning the Dimenſions and Figure of the Earth; the Meridians; Points of the Compaſs; the Variation, Lee-way, Courſe, Diſtance, Log-line, and Half-minute Glaſs; with Rules for knowing when they are truly proportioned to each other.

1. The Circumference of a Meridian on the ſurface of the Earth and Sea is 360 Degrees or 21600 nautical Miles. Each of theſe degrees is a Degree of Latitude, and each mile is a Minute of Latitude.

2. The Circumference of the Equinoctial Line on the ſurface of the Earth and Sea is 360 Degrees or twice 180 Degrees. Each of

theſe degrees is a Degree of Longitude containing 60 Minutes of Longitude.

3. The true North and true South Points of the Horizon, are in the direction of a Meridian, and all the other true points of the Compaſs are deduced from theſe, as in the Diviſions and Subdiviſions of the Compaſs Card.

4. The Variation of the Compaſs, is the number of Degrees and Minutes in the circumference of its circle, which the North Point of the Card declines Eaſtward or Weſtward from the true North Point of the Meridian.

5. Leeway, is the Angle of Difference between the Courſe which a ſhip really makes, and the courſe which ſhe ſeems to make by the poſition of her Head and Stern.

6. The Courſe of a ſhip at ſea is not that which ſhe appears to make in ſailing by the Compaſs Card; but what is compared with the true points of the Horizon. Therefore, the apparent courſe is reduced to the true courſe by adding or ſubtracting the Variation and Leeway, as the caſe requires.

7. The true Courſe is reckoned from the true North toward the true Eaſt or true Weſt, to 8 points or 90 degrees. The like from the true South toward the true Eaſt or true Weſt.

8. The Complement of the Courſe, is its Remainder to 90 Degrees.

9. The Diſtance ſailed is meaſured in Nautical miles, which are between a ſixth and a ſeventh part of the whole, longer than Engliſh ſtatute miles.

10. The Diſtance between Knot and Knot on the Log-line, whereby the ſhip's Diſtance ſailed is meaſured, ſhould be 51 Engliſh feet, when the Half-minute glaſs runs exactly 30 Seconds of time.

11. If the Diſtance between knot and knot be either more or leſs than 51 feet, the Seconds of the half-minute glaſs muſt be more or leſs reſpectively, in the Direct Proportion of 51 to 30.

12. If the Seconds of the Half minute Glaſs are more or leſs than 30, the diſtance between knot and knot on the log-line muſt be more or leſs reſpectively in the direct proportion of 30 to 51.

13. When the Log-line and Half-minute Glaſs are not rightly proportioned to each other.

Multiply the diſtance in Engliſh feet, between knot and knot, by the number of knots run per half-minute glaſs, and 30 times that product is a Dividend. Then, multiply the number of ſeconds of time which the glaſs runs, by 51, and the product is a Diviſor. Make Diviſion, and the Quotient is the number of Nautical Miles per hour which the ſhip runs.

14. A Pendulum that ſwings Seconds of time, meaſures $39\frac{2}{10}$ Inches Engliſh meaſure, from the centre of ſuſpenſion to the centre of motion, ſuppoſing it a ſmall Bullet with a fine Thread or Wire.

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## SECTION VIII.

## DIRECTIONS for computing the uſual Caſes of Plain Sailing by Logarithms; alſo for working by the Table of Difference of Latitude and Departure.

1. To find the Departure.

As the Radius or Sine of 90°
Is to the Diſtance ſailed in miles,
So is the Sine of the Courſe in degrees,
To the Departure in miles.

2. To find the Difference of Latitude.

As the Radius or Sine of 90°
Is to the Diſtance ſailed in miles;
So is the Coſine of the Courſe in degrees,
To the Difference of Latitude in miles.

3. Departure is either Eaſting or Weſting.
Difference of Latitude is either Northing or Southing.

4. To find the Courſe.

As the Difference of Latitude in miles,
Is to the Departure in miles;
So is the Radius or Sine of 90°
To the Tangent of the Courſe in degrees.

5. To find the Diſtance ſailed.

As the Sine of the Courſe in degrees,
Is to the Departure in miles;
So is the Radius or Sine of 90°
To the Diſtance ſailed in miles.

6. To find the Courſe.

As the Diſtance ſailed in miles,
Is to the Radius or Sine of 90°
So is the Difference of Latitude in miles
To the Coſine of the Courſe in degrees.

7. If a ſhip in North Latitude makes Northing, the Difference of Latitude added to the Latitude ſailed from, gives the North Latitude come to.

8. If a ſhip in South Latitude makes Southing, the Difference of Latitude added to the Latitude ſailed from, gives the South Latitude come to.

9. If a ſhip in North Latitude makes Southing, or a ſhip in South Latitude makes Northing, and the Difference of Latitude made is more than the Latitude ſailed from, the ſhip is in a contrary Latitude, by the Difference between them in degrees and minutes.

10. The Difference of Latitude made good, and the Departure made good, are each found from ſeveral Courſes and Diſtances, by help of the Traverſe Table. Then,

11. The Courſe made good and Diſtance ſailed made good, are found by the foregoing Canons.

## SECTION IX.

### DIRECTIONS for computing the uſual Caſes in Mercator's or Wright's ſailing.

1. If two places are both in North Latitude or both in South Latitude, the Difference between their Meridional Parts is their Meridional Difference of Latitude.

2. If two places are one of them in North latitude and the other in South Latitude, the Sum of their Meridional Parts, is their Meridional Difference of Latitude.

3. Longitude from London is reckoned from the Meridian of London at the Equinoctial, Eaſtward to 180 degrees, and Weſtward to 180 degrees. The like for any other Meridian.

4. To find the Difference of Longitude.

As the true Difference of Latitude in minutes,
Is to the Departure in miles;
So is the Meridional Difference of Longitude in parts,
To the true Difference of Longitude in minutes.

5. As the Meridional Difference of Latitude in parts,
Is to the true Difference of Longitude in minutes;
So is the Radius or Sine of 90°.
To the Tangent of the Courſe in degrees.

## SECTION X.

### DIRECTIONS for computing the Caſes of Parallel Sailing.

1. A ſhip ſailing conſtantly Eaſtward or Weſtward without deviating toward the true North or true South point of the Horizon, ſails in a Parallel of Latitude.

2. As the Coſine of the Latitude ſailed in,
Is to the Radius or Sine of 90°.
So is the Diſtance ſailed in miles,
To the Difference of Longitude in minutes.

3. As the Radius or Sine of 90°
Is to the Coſine of the Latitude ſailed in;
So is the Difference of Longitude in minutes,
To the Diſtance ſailed in miles.

## SECTION XI.

### Directions for computing Middle Latitude Sailing.

1. The Half Sum of the Latitude ſailed from, and the Latitude come to, is the Middle Latitude.

2. To find the Difference of Longitude.
As the Coſine of the Middle Latitude,
Is to the Radius or Sine of 90°
So is the Departure in miles,
To the Difference of Longitude in minutes.

3. To find the Departure.
As the Radius or Sine of 90°
Is to the Coſine of the Middle Latitude;
So is the Difference of Longitude in minutes,
To the Departure in miles.

4. In Parallel Sailing the Diſtance ſailed is the Departure in miles; and the Latitude ſailed in, is the Middle Latitude.

## SECTION XII.

### Directions concerning Currents.

1. A ſhip ſailing where there is a Current, ſails between the direction ſhewn by the poſition of her Head and Stern, and the direction of the Current.

2. The Courſe and Diſtance ſailed, as they appear by the log and half-minute glaſs are taken; alſo, the Courſe, and Drift of the Current per hour.

3. From a given point a line is drawn, ſhewing the hourly Courſe and Diſtance ſailed by the preſſure of the wind on her ſails.

4. From the ſame point another line is drawn, ſhewing the hourly Courſe and Diſtance driven by the Current.

5. A Parallelogram is compleated by adding the oppoſite equal ſides.

6 The Diagonal of this Parallelogram, drawn from the given point, is the Path of the ſhip.

7. A Current is accurately taken, by obſervation on the Ship's Wake.

# Calculation of the TIDES.

1784
1. Required the time of High Water at London Bridge May 28?

Calculation. 1784
1
19)1785(93
171
75
57
18 Golden Nº 17
11
30)187(6
180
Epact ....... 7
Nº Month ... 3
Day ...... 28
☽ Age ...... 8
4
5)32(
☽ South .... 6h. 24'
3
High Water .... 9h. 24'

1790
2. Required, time of High Water at Dover October 12th?

Calculation 1790
1
19)1791(94
171
81
76
5 Golden Nº ..... 4
11
30)44(1
30
Epact ....... 14
Nº Month .... 8
Day ..... 12
☽ Age ....... 4
4
[illegible])16(
☽ South 3h. 12'
0.
High Water 3h. 12'

3. Required, the High Water at Lizard Janʸ. 1. 1821?

Calculation. 1821
1
19)1822(95
17 Golden Nº ..16
11
30)176(5
Epact ......... 26
Nº Month .... 0
Day .... 1
☽ Age ...... 27
4
5)108(
☽ South 21h. 36'
7 30
High Water 5h. 6'

4. Required, the High Water at Deal June 6. 1851?

Calculation 1851
1
19)1852(97
9 Golden Nº 8
11
30)88(2
Epact 28
Nº Month ..... 4
Day 6
☽ Age 8
4
5)32(
☽ South 6h. 24'
2. 15
High Water 8. 35

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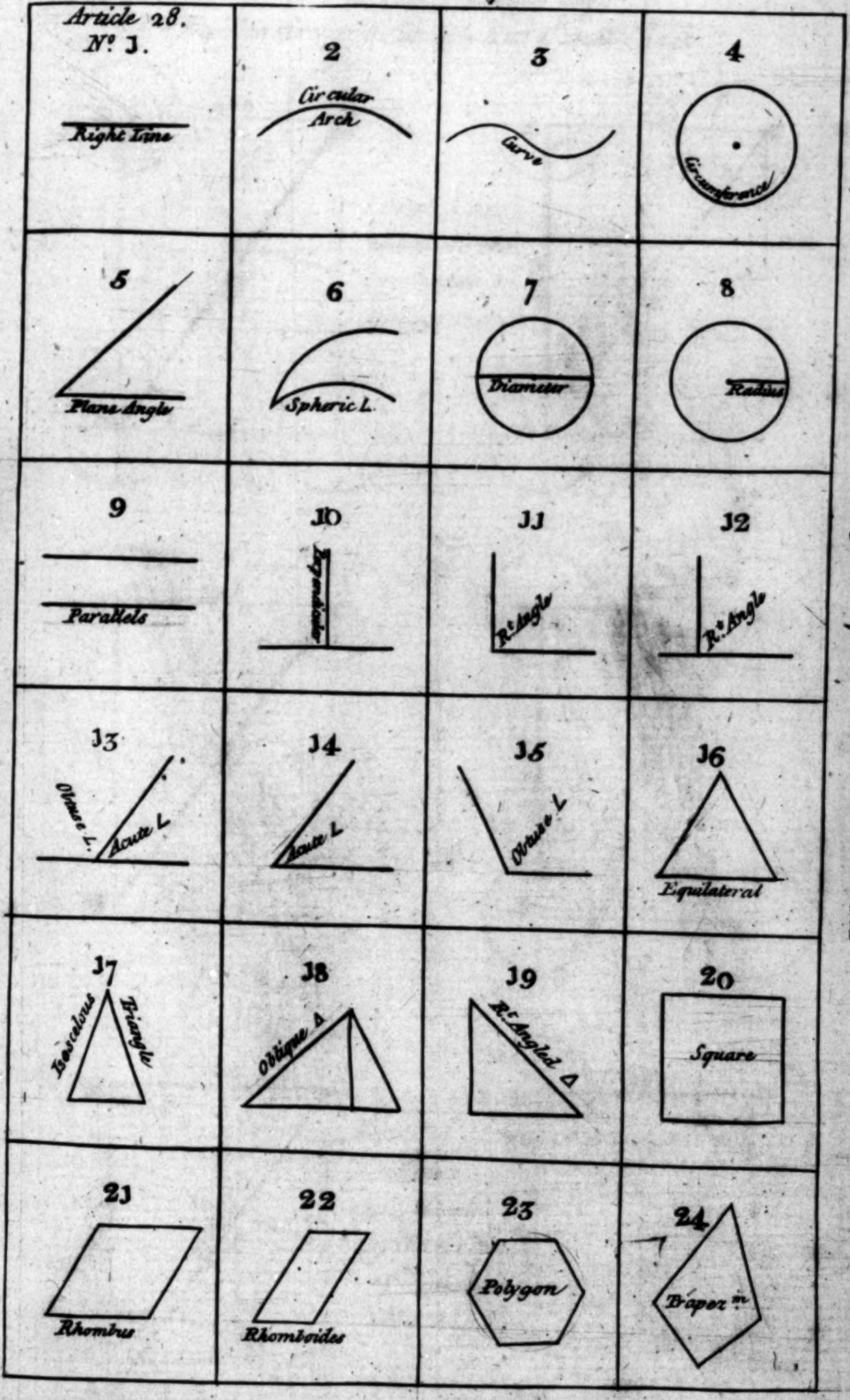
# Geometrical Definitions.



Lines or Angles given are marked thus |

Lines or Angles required are marked thus ○

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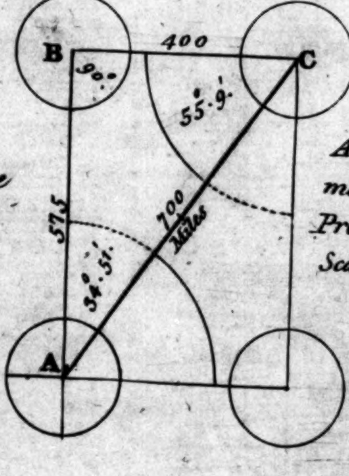
# Plain Sailing.

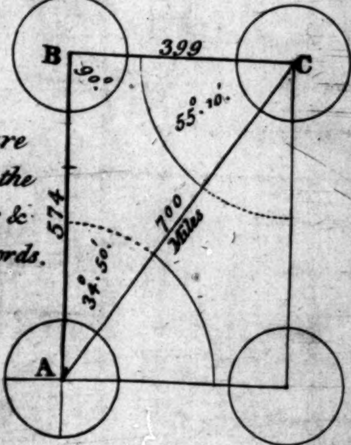
## By Construction, in it's Six Usual Cases.

Case 1.



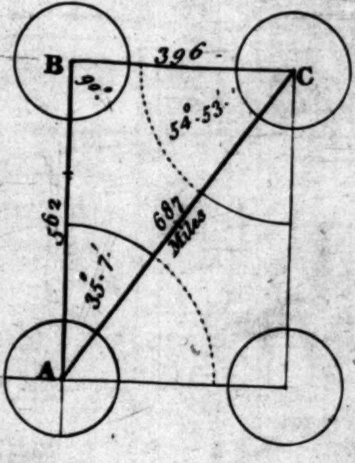
Angles are made by the Protractor & Scale of Chords.

Case 2.

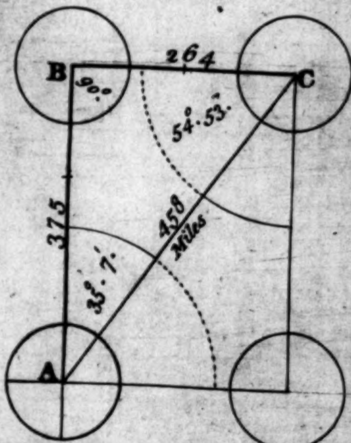


These may be used for Examples.

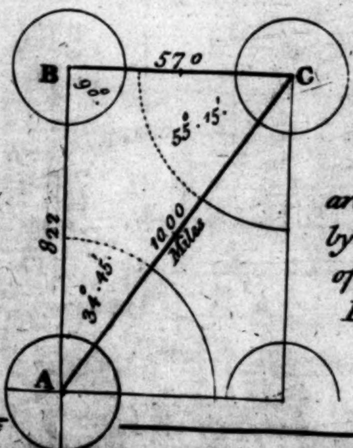
Case 3.



Case 4.

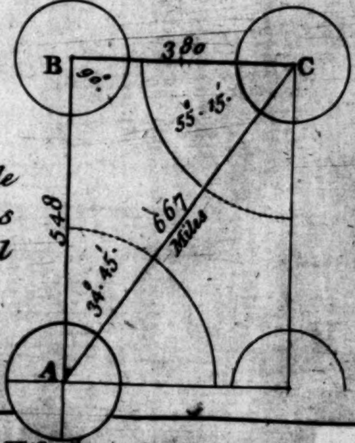


Case 5.



Sides are made by Scales of equal Parts

Case 6.



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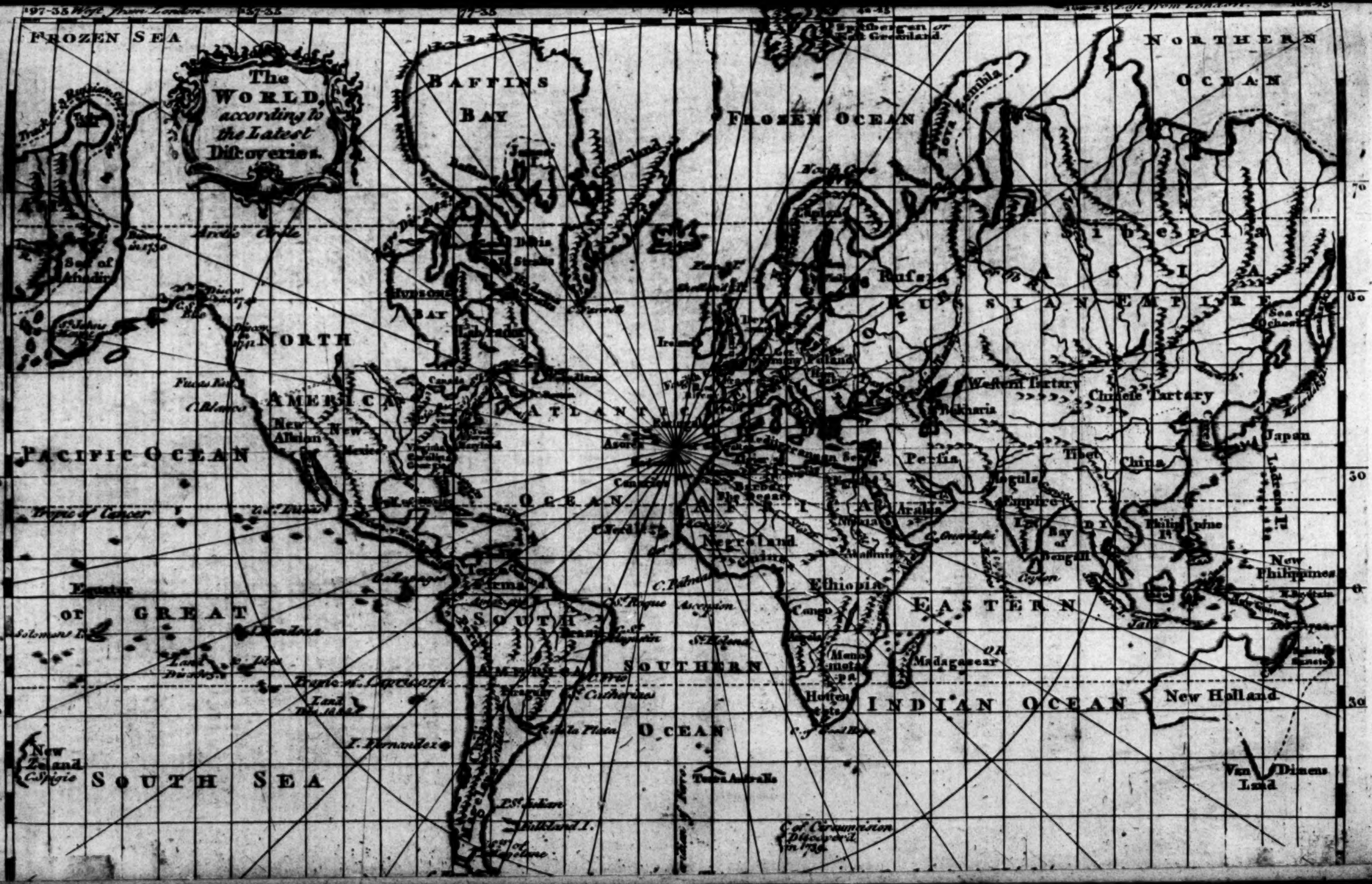
The WORLD, according to the Latest Discoveries.
97-38 West from London.
57-38
77-38
17-38
42-45
East from London.
FROZEN SEA
BAFFINS BAY
FROZEN OCEAN
NORTHERN OCEAN
Spitsbergen or East Greenland.
Greenland
Nova Zembla
North Cape
Sea of Anadir
Arctic Circle
Davis Straits
Hudsons Bay
Labrador
NORTH AMERICA
Canada
New Albion
New Mexico
C. Blanco
PACIFIC OCEAN
Tropic of Cancer
Ireland
ATLANTIC OCEAN
Azores
Canaries
C. Verde Is.
Mediterranean Sea
AFRICA
Barbary
Negroland
Guinea
Ethiopia
Congo
Monomotapa
Hottentots
C. of Good Hope
Madagascar
Arabia
Persia
Russia
RUSSIAN EMPIRE
ASIA
Siberia
Sea of Ochotsk
Western Tartary
Chinese Tartary
Bukharia
Tibet
China
Japan
Moguls Empire
Bay of Bengall
Ceylon
INDIA
Philippine Is.
Ladrone Is.
New Philippines
New Guinea
Java
EASTERN OR INDIAN OCEAN
New Holland
Van Dimens Land
Equator or GREAT
Solomons Is.
Galapagos
Terra Firma
SOUTH AMERICA
Brasil
C. St. Roque
Ascension
St. Helena
SOUTHERN OCEAN
Tropic of Capricorn
St. Catherines
R. de la Plata
I. Fernandez
SOUTH SEA
New Zealand
P. St. Julian
Falkland I.
Terra Australis
C. of Circumcision Discovered in 1739.
70
60
30
0
30

## SECTION XIII.

### DIRECTIONS concerning the Log, and inferring the Place of the Ship from the Courſes and Diſtances ſailed.

1. In long Voyages the Log ſhould be hove every Hour; in ſhort Voyages every two Hours.

2. If the Diſtance between Knot and Knot on the Log-line be ſuppoſedly divided into Ten equal Parts, they will be more eaſily added up in the Reckoning.

3. When two or more Courſes are very nearly alike; they may be added together and divided by the Number of Courſes, to get a Medium; and the Sum of the correſpondent Diſtances ſailed, uſed with that Medium Courſe.

4. When the Diſtances ſailed have been long, the Longitude ſhould be inferred at ſhort Intervals of Time. But in ſhort Diſtances ſailed, the Longitude may be inferred at longer Intervals of Time.

5. The Error ariſing from one ſuch Inferrence, ſhould not exceed a Minute of Longitude.

## SECTION XIV.

### DIRECTIONS for applying the different Kinds of Sailing at different Places.

1. The Tropic of Cancer, on the Earth and Sea, is a Circle at the diſtance of 23 Degrees and 28 Minutes Northward from the Equinoctial Line.

2. The Tropic of Capricorn, is a like Circle at the ſame diſtance Southward of the Equinoctial.

3. The Torrid Zone is the ſpace between the Tropics.

4. The North Temperate Zone, extends 43 Degrees and 4 Minutes more Northwardly than the Torrid Zone, or to within 23 Degrees and 28 Minutes of the North Pole.

5. The South Temperate Zone extends the like diſtance, more Southward than the Torrid Zone.

6. The remaining parts, Land or Sea, round the North Pole, are in the North Frigid Zone.

7. The like parts round the South Pole, are in the South Frigid Zone.

8. Plain Sailing may be applied near the Equinoctial.

9. Mercator's Sailing ſhould be applied near the Poles.

10. Either Mercator's, or Middle Latitude Sailing, ſhould be applied at other places.

## SECTION XV.

### DIRECTIONS for adjuſting Hadley's Octant and Sextant, in order to make an Obſervation.

1. The Beginning of the Index ſhould be put to the Beginning of the Octant or Sextant, previous to every Adjuſtment.

2. The Foot of the Great Mirror ſhould be formed at Right Angles to the Plane of the Cell, that is to hold the Glaſs.

3. The Great Mirror has then its Foot ſcrewed down flat, on the Plane of the Index, near the centre.

4. The Sight Hole in the Eye Piece, ſhould be the ſame Diſtance from the plane of the inſtrument, as the Line between the quickſilvered and the unquickſilvered part on the ſmall Mirror.

5. Hold the Inſtrument horizontally, and move the ſmall Mirror, until an horizontal Line at a Diſtance, appears continued as one, both on and off the quickſilvered part of the ſmall Mirror.

6. Put the beginning of the Index to the beginning of the Inſtrument, and holding the Inſtrument vertically, turn the ſmall Mirror, until any object appears perfect; partly on the quickſilvered and partly on the unquickſilvered part of the ſmall Mirror.

7. The Objects whereby both of theſe adjuſtments may be correctly made, ſhould not be leſs than half a mile off.

8. Some Inſtruments have the Foot of the Great Mirror, not at Right Angles to the Glaſs; ſuch may be adjuſted by the following method.

9. Let the Eye-hole in the Eye piece be the ſame height from the Plane of the Inſtrument, as the Line between the quickſilvered and unquickſilvered part of the ſmall Mirror.

10. Cut out a parallelogram Piece of dark Paper of the length of the Great Mirror, and ſuch a breadth, that when ſtuck on the lower part of the Great Mirror, it may cover it to the height of the quickſilvered part on the ſmall Mirror.

11. Adjuſt both of the Mirrors, until the reflected top of the Paper appears coincident with the Line between the quickſilvered and unquickſilvered Part of the ſmall Mirror.

12. If it may be ſuppoſed, that the great and ſmall Mirrors do not both ſtand exactly perpendicular to the Plane of the Inſtrument, after the foregoing Adjuſtment, it may be verified farther thus.

13. Take a thin plate of Braſs whoſe length is that of the Great Mirror, with its foot at right angles to its height, and height ſuch that when placed upright on its foot before the Great Mirror, the Edge of the forementioned Paper, the Edge of this Plate, the Line between the quickſilvered and unquickſilvered part on the ſmall mirror, and the Sight-hole, may be the ſame Diſtance from the Plane of the Inſtrument.

14. Adjuſt both the great and ſmall Mirror until theſe three Edges

by direct and reflected viſion are in one, and it is the horizontal adjuſtment required.

## SECTION XVI.

### DIRECTIONS for joining the Objects obſerved, in uſing Hadley's Octant or Sextant.

1. The Line of Separation between the quickſilvered and the unquickſilvered part of the ſmall Mirror, may not be improperly called the Object Line.

2. In all obſervations with the inſtrument, the Objects ſhould be brought at contact with each other in the Object Line.

3. The Adjuſtment of the Inſtrument ſhould be re-examined after the Obſervation.

## SECTION XVII.

### DIRECTIONS for taking the Meridian Altitude of the Sun or Moon, with Hadley's Octant or Sextant.

1. The lower Limb of the Sun is always brought to ſweep the Horizon of the Sea.

2. The Sun's Semidiameter muſt be added, but the Refraction and Dip correſponding to that altitude ſubtracted, to get the true altitude of the Sun's Centre.

3. The Moon's lower or upper Limb is brought to the Horizon, that of the two which is viſible.

4. When the lower Limb of the Moon is obſerved, the Moon's Semidiameter muſt be added, but the Refraction and Dip ſubtracted, to get the altitude of the Moon's Centre.

5. When the upper Limb of the Moon is obſerved, the Moon's Semidiameter muſt be ſubtracted, alſo the Refraction and Dip muſt be ſubtracted, to get the altitude of the Moon's Centre.

6. The Altitude thus found is only that which reſpects the Horizon of the Sea. But the Moon's true Altitude with reſpect to the Horizon paſſing through the Earth's Centre is greater by the Parallax in Altitude.

7. As the Radius or Sine of 90°
Is to the Coſine of the Moon's Altitude;
So is the Moon's horizontal Parallax in Seconds,
To the Parallax in Altitude in Seconds.

8. A Star is brought to touch the Horizon of the Sea, and the Refraction and Dip are ſubtracted.

## SECTION XVIII.

### Directions concerning the Meridian Altitudes of the Celeſtial Bodies, at different Places of the Earth and Seas.

1. On any Day, the Altitude of the Sun is greateſt when his Centre is on the Meridian of the place of obſervation.

2. A Direct Obſervation is made by bringing the Object to the Horizon before you.

3. In the North-temperate and North-frigid Zones, you face the South, to ſee the Sun on the Meridian.

4. In the South-temperate and South-frigid Zones, you face the North, to ſee the Sun on the Meridian.

5. In the Torrid Zone, you ſometimes face the North, and at other times the South, to ſee the Sun on the Meridian.

6. In the Torrid Zone, North of the Equinoctial Line, you face the South to ſee the Sun on the Meridian when the Sun hath South Declination, and when his North Declination is leſs than the Latitude of the Place.

7. In the Torrid Zone, South of the Equinoctial Line, you face the North to ſee the Sun on the Meridian when the Sun hath North Declination, and when his South Declination is leſs than the Latitude of the Place.

8. If in the Torrid Zone, North of the Equinoctial, you face the North to ſee the Sun on the Meridian; or in the Torrid Zone South of the Equinoctial, you face the South to ſee the Sun on the Meridian: in either of theſe caſes, the Latitude is leſs than the Sun's Declination.

9. The Meridian Altitude of the Equator, is the Co-latitude, or it's remainder to 90°.

10. The Sun on the Meridian, never exceeds 23 Degreees and 28 Minutes, above or under the Meridian Altitude of the Equator.

11. In the Frigid Zones, the Sun (alſo the Stars) may have two Meridian-Altitudes; one above, the other under the Pole.

12. In the other Zones, the Stars near the Poles, may have the like.

## SECTION XIX.

### Directions for taking the Latitude at Sea, by Meridian Altitudes of the Sun.

1. Take the Meridian Altitude of the Sun's lower Limb, and add thereto the Semidiameter, but ſubtract the Refraction and Dip, this gives the Meridian Altitude of the Sun's Centre.

2. If you face the South and the Sun hath $\begin{Bmatrix}\text{South}\\\text{North}\end{Bmatrix}$ Declination, $\begin{Bmatrix}\text{add}\\\text{ſubtract}\end{Bmatrix}$ the Declination $\begin{Bmatrix}\text{to}\\\text{from}\end{Bmatrix}$ the Meridian Altitude; this gives either the Co-latitude, or its Supplement.

3. If you face the North and the Sun hath $\begin{Bmatrix}\text{North}\\\text{South}\end{Bmatrix}$ Declination, $\begin{Bmatrix}\text{add}\\\text{ſubtract}\end{Bmatrix}$ the Declination $\begin{Bmatrix}\text{to}\\\text{from}\end{Bmatrix}$ the Meridian Altitude; this gives either the Co-latitude, or its Supplement.

4. If you face the North, and the Sun's Declination is North, and the Meridian Altitude added to the Declination makes exactly 90°. Or otherwiſe, if you face the South, and the Sun's Declination is South, and the Meridian Altitude added to the Declination makes exactly 90° in either of theſe two caſes, you are at the Equinoctial Line.

5. If you face the $\begin{Bmatrix}\text{North}\\\text{South}\end{Bmatrix}$ and the Sun's Declination is $\begin{Bmatrix}\text{North}\\\text{South}\end{Bmatrix}$ and the Meridian Altitude added to the Declination makes more than 90° you are in $\begin{Bmatrix}\text{North}\\\text{South}\end{Bmatrix}$ Latitude, and the Meridian Altitude added to the Declination gives the Supplement of the Co-latitude. Take this Supplement from 180° the Remainder is the Co-latitude. Or, take 90° from the Supplement, the Remainder is the Latitude.

## SECTION XX.

### DIRECTIONS for taking the Latitude at Sea, by Meridian Altitudes of the Fixed Stars.

1. Fixed Stars change their Declination a little every Year, either increaſing or decreaſing.

2. Before they are uſed in finding the Latitude, their Declinations muſt be corrected to the time of Obſervation.

3 Their Semidiameter is nothing, but their Refraction and Dip, are both to be ſubtracted from their obſerved Meridian Altitudes, to get the true Altitudes of the Centre.

4. The Latitude is determined by having the Meridian Altitude of the Centre of a Fixed Star; as it is determined by that of the Sun.

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## SECTION. XXI.

### Directions for finding the Diſtance of the viſible Horizon at Sea.

1. The Diameter of the Earth's Globe is 7942 Engliſh Miles nearly, or 41933760 Engliſh Feet, and the Logarithm of theſe Feet is 7,6225639.

2. In an Engliſh Mile are 5280 Feet, whoſe Logarithm is 3,7226339, whoſe double is 7,4452678, which being taken from the former Logarithm, the Remainder is 0,1772961, or being contracted, it is 0,1773.

3. To this conſtant Logarithm 0,1773, add the Logarithm of the Height of the Eye above the ſurface of the Sea in Feet, and Half that Sum is the Logarithm of the Diſtance in Miles, which you may ſee the Surface of the Sea, from that Height.

4. From the Double Logarithm of the Diſtance, which the ſurface of the Sea can be ſeen in Miles, ſubtract the conſtant Logarithm 0,1773; and the Remainder is the Logarithm of the Height of the Eye above the Surface of the Sea in Feet.

## SECTION XXII.

### Directions for knowing the Hour at the firſt Meridian, having the Hour at the Ship and it's Longitude.

1. The Meridian of St. Paul's, London, is commonly called the firſt Meridian, by Britiſh Navigators; but the Britiſh aſtronomical Tables are adapted to the Meridian of Greenwich Obſervatory, which is nearly 6 Minutes of a Degree of Longitude, eaſtward from St. Paul's, London.

2. Every Degree of Longitude, Eaſtward or Weſtward from the firſt Meridian, anſwers to 4 Minutes of Time, and every Hour of Time anſwers to 15 Degrees of Longitude.

3. When a Ship is any where, on the ſame Side of this firſt Meridian, it is the ſame Hour and Minute of the Day or Night at the Ship, as at London.

4. When the Ship is $\left\{\begin{array}{c}\text{Eaſtward}\\ \text{Weſtward}\end{array}\right\}$ of the firſt Meridian it is $\left\{\begin{array}{c}\text{more}\\ \text{leſs}\end{array}\right\}$ time of the Day or Night, at the Ship, than it is at London at the ſame inſtant.

5. When the Ship is $\left\{\begin{array}{c}\text{Eaſtward}\\ \text{Weſtward}\end{array}\right\}$ of this firſt Meridian, the Hour at the Ship $\left\{\begin{array}{c}\text{diminiſhed}\\ \text{augmented}\end{array}\right\}$ by the Ship's Longitude in Time from London, gives the Hour at London.

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## SECTION XXIII.

### Directions for knowing the Sun's true Declination, when the Longitude of the Ship is nearly known.

1. The Sun's Declination in the Britiſh aſtronomical Tables, is computed for every Day in the year at Noon, as it is found either at Greenwich or London.

2. Near the time of the Summer and Winter Solſtices, the Declination is nearly the ſame during 24 hours; but near the time of the Equinoxes the Declination changes conſiderably during 24 Hours.

3. As 24 Hours, is to the daily difference of Declination; ſo is any leſs Number of Hours, to the change of Declination in that Interval. This $\left\{\begin{array}{c}\text{added to}\\ \text{ſubtracted from}\end{array}\right\}$ the Declination of the foregoing Noon for Greenwich, when the Declination is $\left\{\begin{array}{c}\text{increaſing}\\ \text{decreaſing}\end{array}\right\}$, gives the Declination at the given Hour.

4. Thus, the Sun's Declination is found for any given Hour at the Ship, when the Ship's Longitude is known ſomewhat near the Truth.

## SECTION XXIV.

### Directions for finding the Variation of the Compaſs at Sea by Amplitudes.

1. The true Eaſt, true Weſt, true North and true South Points of the Horizon, do not appear at Sea, but are inviſible; nevertheleſs they are underſtood to exiſt.

2. The falſe Eaſt, falſe Weſt, falſe North and falſe South Points of the Horizon, are ſhewn by the Card, in either the Steering Compaſs or the Azimuth Compaſs.

3. When the lower Edge of the Sun appears Half his Diameter above the Horizon, the Centre of the Sun is then nearly in the Horizon; this is the time for taking the Amplitude, either at Sun Riſing or Sun Setting.

4. The true Amplitude is reckoned from the true Eaſt at Sun Riſing, and from the true Weſt at Sun Setting; toward the true North or true South, in Degrees and Minutes.

5. The falſe Amplitude is taken and reckoned from the falſe Eaſt at Sun Riſing, and from the falſe Weſt at Sun Setting; toward the falſe North or falſe South, in Degrees and Minutes.

6. Whilſt the Sun hath North Declination, the Sun riſeth Northward of the true Eaſt, and ſets Northward of the true Weſt.

7. Whilſt the Sun hath South Declination, the Sun riſeth Southward of the true Eaſt, and ſets Southward of the true Weſt.

8. As the Coſine of the Latitude,
Is to the Radius or Sine of 90°.
So is the Sine of the Sun's Declination,
To the Sine of the true Amplitude.

9. In the Circumference of a ſmall Circle, repreſent the true Eaſt and true Weſt, true North and true South; and from the true Eaſt for Sun Riſing, or true Weſt for Sun Setting, ſet off the true Amplitude toward the true North or true South, to the true horizontal Place of the Sun.

10. From that Place of the Sun, ſet off the falſe Amplitude, to the falſe Eaſt or falſe Weſt, ſhewn by the Compaſs Card.

11. If the falſe Amplitude coincides with and is equal to the true Amplitude, the falſe North will coincide with the true North and there will be no Variation.

12. The falſe North declines as much, and the ſame Way, from the true North, as the falſe Eaſt doth from the true Eaſt, or the falſe Weſt doth from the true Weſt.

13. When the falſe Amplitude and true Amplitude, are both Northwardly or both Southwardly, their Difference is the Variation.

14. When the falſe Amplitude and true Amplitude, are one Northwardly and the other Southwardly, their Sum is the Variation.

15. When the $\left\{\begin{matrix}\text{true}\\ \text{falſe}\end{matrix}\right\}$ Amplitude $\left\{\begin{matrix}\text{northwardly}\\ \text{ſouthwardly}\end{matrix}\right\}$ is $\left\{\begin{matrix}\text{greateſt}\\ \text{leaſt}\end{matrix}\right\}$ at Sun $\left\{\begin{matrix}\text{Setting}\\ \text{Riſing}\end{matrix}\right\}$ the Variation is Eaſtwardly.

16. When the $\left\{\begin{matrix}\text{true}\\ \text{falſe}\end{matrix}\right\}$ Amplitude $\left\{\begin{matrix}\text{northwardly}\\ \text{ſouthwardly}\end{matrix}\right\}$ is $\left\{\begin{matrix}\text{greateſt}\\ \text{leaſt}\end{matrix}\right\}$ at Sun $\left\{\begin{matrix}\text{Riſing}\\ \text{Setting}\end{matrix}\right\}$ the Variation is Weſtwardly.

17. If any Difficulty ariſeth concerning this, a ſmall Circle ſhould be drawn and quartered, and in the Circumference the true and falſe Amplitudes ſet off, for ſhewing the Addition or Subtraction to get the Variation.

## SECTION XXV.

## DIRECTIONS for finding the Variation of the Compaſs at Sea, by Azimuths.

1. The true North and true South Points of the Horizon, do not appear at Sea, but are inviſible, nevertheleſs they are underſtood to exiſt.

2. The falſe North and falſe South Points of the Horizon, are ſhewn by the Card in either the Steering Compaſs or the Azimuth Compaſs.

3. When the Sun is elevated above the Horizon, you ſuppoſe a Perependicular to drop down from the Sun to the Horizon, and from that Point in the Horizon to the true North Point in the Horizon, is the Sun's true Azimuth from the North. The Supplement or Remainder to 180 Degrees, is the true Azimuth from the South.

4. In North Latitude, the true Azimuth is reckoned from the true North Point of the Horizon; but in South Latitude, the true Azimuth is reckoned from the true South Point of the Horizon.

5. The falſe Azimuth is obſerved by the Compaſs Card, and is reckoned from the North Point of the Compaſs Card in North Latitude, but from the South Point of the Compaſs Card in South Latitude.

6. The true Azimuth from the North in North Latitude, and from the South in South Latitude, are each of them computed by this Rule.

1ſt. If the Declination and Latitude are either both North or both South, ſubtract the Declination from 90° but otherwiſe add the Declination to 90° to get the Polar Diſtance.

2d. When the Sun's Altitude has been taken, if it is ſmall, ſubtract the Refraction from it as well as the Dip, to get the Altitude of the Centre.

3d. Add together the Co-latitude, the Co-altitude and the Polar Diſtance; take half that Sum, and from that Half Sum, ſubtract the Polar Diſtance to get a Remainder.

4th. Add together the Complement-arithmetical of the Co-latitude, the Complement-arithmetical of the Co-altitude, the Sine of the Half Sum and the Sine of the Remainder, take the Half Sum of theſe four Logarithms and find it in Logarithmic Sines.

5th. Take the correſpondent Co-ſine Arch and double it, this is the true Azimuth from the North in North Latitude, and from the South in South Latitude.

7. If the falſe Azimuth coincides with and is equal to the true Azimuth, the falſe North will coincide with the true North and there will be no Variation.

8. When the $\left\{\begin{matrix}\text{true}\\ \text{falſe}\end{matrix}\right\}$ Azimuth in $\left\{\begin{matrix}\text{North}\\ \text{South}\end{matrix}\right\}$ Latitude, is greateſt Beforenoon, the Variation is Eaſtwardly.

9. When the $\left\{\begin{matrix}\text{true}\\ \text{falſe}\end{matrix}\right\}$ Azimuth in $\left\{\begin{matrix}\text{North}\\ \text{South}\end{matrix}\right\}$ Latitude, is greateſt Afternoon, the Variation is Weſtwardly.

10. Count both the falſe and true Azimuth, from the North in North Latitude and from the South in South Latitude; then,

when the falſe and true Azimuths are of one Name, their Difference is the Variation.

11. When the falſe and the true Azimuths are of different Names, their Sum is the Variation.

## SECTION XXVI.

### DIRECTIONS for referring two Obſervations to one Station, when the Latitude is to be found by having two Altitudes and the Elapſed Time.

1. When a Ship in Motion is in an unknown Latitude, and her Latitude is to be determined by two Altitudes and the Elapſed Time; the Place where the firſt Altitude is taken, is called the firſt Station, and the Place where the ſecond Altitude is taken the ſecond Station.

2. If the Ship ſails due Eaſt or due Weſt directly $\left\{\begin{array}{c}\text{toward}\\ \text{from}\end{array}\right\}$ the Sun all the Way; the Diſtance ſailed in Miles, are Minutes to be $\left\{\begin{array}{c}\text{ſubtracted from}\\ \text{added to}\end{array}\right\}$ the Altitude taken at the ſecond Station, to reduce it to what it would have been at the firſt Station.

3. If the Ship ſails under any other Courſe, and directly toward the Sun all the Way, the Trace of the Ship will be a Curve, concave or convex to the neareſt Diſtance between the two Stations.

4. The Bearing of the Sun by the Compaſs, at the firſt Station, is the firſt Bearing, and at the ſecond Station, is the ſecond Bearing, their Difference is the Difference of the Bearings; and the Diſtance made good between the Stations, in Miles are Minutes of a Degree.

5. The Difference of the Bearings, is an Angle (at the firſt Station) of a Right Angled Plane Triangle; the Diſtance made good is it's Hypothenuſe, a Perpendicular drawn from the ſecond Station to the Line of firſt Bearing forms the Right Angle, and from the firſt Station to the Right Angle are the Miles (or Minutes) ſhewing the Increaſe or Decreaſe of Altitude between the two Stations.

6. When the ſecond Station is at Right Angles to the firſt Bearing, this Difference of Altitude is nothing.

7. When the ſecond Station is $\left\{\begin{array}{c}\text{advanced more toward}\\ \text{withdrawn more from}\end{array}\right\}$ the Sun, than the firſt Station, the Difference of Altitude is $\left\{\begin{array}{c}\text{ſubductive from}\\ \text{additive to}\end{array}\right\}$ the Altitude at the ſecond Station to reduce to what it would have been at the firſt Station.

8.

8. As the Radius or Sine of 90°
Is to the Diſtance made good in Miles;
So is the Coſine of the Difference of Bearings,
To the Difference of Altitude required.

9. When a Ship hath run under different Courſes and Diſtances from the firſt to the ſecond Station; the Courſe and Diſtance made good are to be found as in Traverſe Sailing.

10. The Diſtance made good thus found, is to be applied as a ſingle Courſe with its Diſtance beforementioned, to reduce the Altitude at one Station to what it would be at the other Station.

## SECTION XXVII.

### DIRECTIONS for judging nearly what the Latitude is, from an Altitude of the Sun or Star, or the Moon cleared from Parallax in Altitude; when ſuch an Altitude is taken near the Meridian.

1. Where the Declination and Latitude are both North or both South, ſubtract the Declination from 90° but otherwiſe add it to 90° to get the Polar-diſtance.

2. When the Sun or other Celeſtial Body, is on the Meridian, the Co-altitude and Co-latitude together, are equal to the Polar-diſtance.

3. When the Sun or other Celeſtial Body is not on the Meridian, the Co-altitude and Co-latitude together, are greater than the Polar-diſtance.

4. When the Co-altitude and the ſuppoſed Co-latitude together are leſs than the Polar-diſtance, the ſuppoſed Co-latitude is too little, and the Latitude too great.

5. When the Co-altitude and the Polar-diſtance together are greater than the ſuppoſed Co-latitude, the Co-latitude is too great, and the Latitude too ſmall.

6. In either of theſe three laſt-mentioned Caſes, it will be ſhewn how to judge more nearly whether the ſuppoſed Latitude is too great or too little, and how to aſſume it nearer the Truth.

## SECTION XXVIII.

### DIRECTIONS for finding the Latitude at Sea, by having two Altitudes of the Sun and the Time Elapſed between the Obſervations.

1. The Altitude of the Sun's lower Limb muſt be taken at the firſt Station, and cleared of Semidiameter, Refraction and Dip, to get the Altitude of the Centre.

2. The Bearing of the Sun at the firſt Station muſt be taken by the Compaſs, when the firſt Altitude is taken.

3. The Diſtance made good from the firſt Station to the ſecond Station, muſt be found by Plain Sailing.

4. The Altitude of the Sun's lower Limb muſt be taken at the ſecond Station, and cleared of Semi-diameter, Refraction and Dip, to get the Altitude of the Centre.

5. The Bearing of the Sun at the ſecond Station muſt be taken by the Compaſs when the ſecond Altitude is taken.

6. Having the two Bearings, the Diſtance between the two Stations, and the two Altitudes of the Sun's Centre; the Altitude of the Sun's Centre at the ſecond Station muſt be reduced to what it would have been, if it had been taken at the firſt Station.

7. The Sun's Declination muſt be taken out as nearly as poſſible, what it is at the Middle between the two Obſervations for London or Greenwich, in Degrees and Minutes.

8. If the Declination and Latitude are ſuppoſed both North or both South, ſubtract the Declination from 90° but otherwiſe add the Declination to 90° to get the Polar Diſtance.

9. Take two Latitudes as near the truth as you can ſuppoſe, one of them that ſhewn by the Ship's Reckoning or any other way choſen, and the other a Degree, or more or leſs different therefrom; and ſuch, that of the Co-latitudes, either of the Co-altitudes, and the Polar Diſtance, any two of the three may be greater than the third.

10. The firſt choſen Co-latitude, the Polar-diſtance, and the two obſerved Co-altitudes, will form two Computations; and the ſecond choſen Co-latitude, the Polar-diſtance, and the two obſerved Co-altitudes, will form two other Computations.

11. The Elapſed-time muſt be found from the two firſt Computations, likewiſe from the latter Computations, by this Rule.

1ſt. Add together, the Co-latitude, the Polar-diſtance and Co-altitude, and from their half Sum ſubtract the Co-altitude, to get a Remainder.

2d. Add together the Complement-arithmetical of the Co-latitude, the Complement-arithmetical of the Polar-diſtance, the Sine of the half Sum and the Sine of the Remainder, and take half the Sum.

3d. Find this half Sum in Logarithmic ſines, take out the correſpondent Coſine-arch and double it; this in Degrees, allowing 15 Degrees to an Hour of Time, is the computed Time from Noon, when that Obſervation was made.

12. Each of the two firſt Hour-angles, muſt be found by this Rule; likewiſe, each of the two ſecond Hour-angles by the ſame Rule.

13. The meaſured Elapſed-time between the two obſervations, muſt be turned into Degrees, by allowing 15 Degrees to an Hour of Time.

14. When the $\left\{\begin{matrix}\text{Sum}\\ \text{Difference}\end{matrix}\right\}$ of the two Hour-angles thus found, agrees nearer with the meaſured Elapſed-time than their $\left\{\begin{matrix}\text{Difference}\\ \text{Sum}\end{matrix}\right\}$ the Obſervations were made $\left\{\begin{matrix}\text{one before, the other}\\ \text{both before or}\end{matrix}\right\}$ Afternoon.

15. When either the Sum or the Difference of the computed Elapſed-time, agrees with the meaſured Elapſed-time, the Latitude correſponding thereto is the true Latitude.

16. Take the Difference between the computed Elapſed-times in Degrees and Minutes; and the Difference between the two aſſumed Latitudes in Minutes of a Degree.

17. As the Difference between the computed Elapſed-times,
Is to the Difference between the aſſumed Latitudes;
So is the meaſured Elapſed-time,
To a number of Minutes, for the Correction.

18. If the Latitude thus found, gives the meaſured Elapſed-time, it is the true Latitude.

19. If neither of the aſſumed Latitudes agrees with the Latitude thus found, that Latitude neareſt agreeing therewith (if it will work) is to be aſſumed, and the Operation made therewith as before to find the computed Elapſed Time.

20. Compare this newly computed Elapſed Time with one of the former Elapſed Times, by the forementioned Proportion, and it will give the Correction required.

21. When the Latitude is known, either by this Method, or by having the Meridian Altitude; (the Declination, and the Altitude being known) the time of the Day, either paſt Noon or what it wants of Noon, is found by the three ſteps in the foregoing Article.

22. If this computed Time agrees with that ſhewn by the Ship's Clock, it is right with Solar-time; but otherwiſe, it ſhould be ſet forward or backward, or its Difference allowed for.

## SECTION XXIX.

### DIRECTIONS for reducing the apparent Courſe to the true Courſe, by an Allowance for Lee-way and Variation, to have the true Rhomb,

1. Lee-way may augment or diminiſh the Angle which the Ship makes with the true Meridian. Variation may likewiſe augment or diminiſh the Angle made with the true Meridian.

2. Either the Sum or Difference of Leeway and Variation may be the Correction additive or ſubductive, to reduce the apparent Courſe to the true Courſe.

3. The true Courſe is every where the ſame, between any two places whoſe Bearing and Diſtance are to be expreſſed.

4. The Diſtance under this uniform Courſe, is no where coinciding with a Great Circle, except along a Meridian or the Equinoctial.

## SECTION XXX.

### Directions concerning the Plain Chart.

1. The Plain Chart may be uſed, within the Limits of about ten Degrees North and South of the Equinoctial; but in approaching toward the Poles, it becomes erroneous.

2. In the Plain Chart, the Degrees of Latitude and of Longitude, are equal to each other; each being 60 nautical Miles.

3. When a ſmall part of the Earth or Sea is to be repreſented; the Meridians may be ſtraight Lines parallel to each other. Likewiſe, the parallels of Latitude may be ſtraight Lines parallel to each other, and at right Angles to the Meridians.

4. In the laſt-mentioned caſe, the Degrees of Latitudo are equal. The Degrees of Longitude are alſo equal; but a Degree of Latitude is to a Degree of Longitude, as the Radius is to the Coſine of the Latitude.

## SECTION XXXI.

### Directions concerning the Bearings and Diſtances of Places, as ſhewn by the true Sea Chart.

1. The Parallel Bearings or Courſes are ſhewn by the Compaſs-points on the Chart.

2. The Diſtances on the Meridians are ſhewn by the Degrees of Latitude.

3. Having the Bearing and the true Difference of Latitude; the Diſtance is found by this Rule. As the Coſine of the Courſe in Degrees and Minutes, is to the true Difference of Latitude in Miles; ſo is the Sine of 90° to the Diſtance in Miles.

4. In meaſuring obliquely and by Scale of equal Parts, the Scale muſt be a Medium of the Difference between what ariſeth from the Equidiſtance of the Meridians and the Enlargement of the Degrees of Latitude.

## SECTION XXXII.

### Diections for uſing the Sinical Quadrant.

1. The Sinical Quadrant ſhews the lengths of the Natural Sines and Coſines, to every part of the Quadrant, the Radius being ſuppoſed Unity, or rather 10, or 100, or 1000, &c.

2. The Radius being equally divided; any number of Miles may be found therein, anſwering to the Diſtance ſailed.

3. In the Sinical Quadrant; any part of the Radius repreſenting the Diſtance ſailed is the Hypothenuſe of a right-angled plane Triangle, in which, the Baſe and Perpendicular are one of them the Difference of Latitude and the other of them the Departure; and the Courſe is the Angle at the Centre made with the Meridian.

4. Conſequently, the Sinical Quadrant, ſolves all the caſes of Plain Sailing, by Inſpection.

## SECTION XXXIII.

### DIRECTIONS for uſing the Plain Scale.

1. The Plain Scale hath Equal Parts, Chords, Sines, Tangents, Semi-tangents Secants, &c.

2. The Equal Parts are uſed in laying down the Sides of Plane Triangles; the Chords in making or meaſuring their Angles; the Sines and Semi-tangents in Projections of the Sphere in Plano; the Tangents and Secants in the ſame doctrine.

3. Theſe Lines are likewiſe applicable in Dialling, but have not many other uſes in Navigation.

## SECTION XXXIV.

### DIRECTIONS for the Conſtruction of Plane Triangles; alſo, for the Caſes of Plain and Mercator's Sailing.

1. Sides of Plane Triangles, are laid down by Scales of Equal Parts.

2. Angles of Plane Triangles, are laid down by Scales of Chords, or by the Protractor.

3. In Scales adapted for laying down Angles in Points of the Compaſs, the Points of the Compaſs are proportional to the Degrees contained in them.

4. The Chord of 60° is always the Radius of the Circle.

5. If a leſſer Scale be required than that which is conſtructed; you may uſe any part of the Radius for a Radius, provided you uſe the ſame proportional part, for the Chords of any of the Arches.

## SECTION XXXV.

### DIRECTIONS concerning the Uſe of the Sector.

1. The Sector hath a Scale of Lines of Equal Parts; alſo, of Natural Sines, Tangents, Secants, &c.

2. The two Legs of the Sector have Lines alike, and alike graduated from the Centre to the End.

3. Either Leg of the Sector may be uſed as a Scale of Equal Parts. But, when the Sector is otherwiſe uſed, it is thus,

4. In taking off any Diſtance or Length from the Sector, the two points of the Dividingcompaſs are extended from one diviſion on the one Leg, to the like diviſion on the other Leg of the Sector.

5. By this property, the Sector becomes an univerſal ſcale of Natural Sines, Tangents, &c. as well as Equal Parts, and thereby ſupplieth the uſe of many Scales.

6. Proportionality or Direct Proportion is performed by the Sector, thus. As any Number on one of the Legs; is to the Parallel Breadth from one Leg to the other, at any opening of the Sector; ſo is any other Number on the firſt mentioned Leg, to a Parallel Breadth from one Leg to the other, which is the fourth Number required.

7. Every operation on the Sector, in working Proportionality, depends on the doctrine of Similar Triangles.

8. The Sector, ſometimes hath Gunter's Lines near the Edge of its Legs, which are worked by the help of a pair of Compaſſes.

## SECTION XXXVI.

### DIRECTIONS concerning Gunter's Scales.

1. Gunter's Lines of Numbers, Sines, Tangents, &c. are of two kinds. The former are commonly called Scales and Compaſſes, the latter Sliding-Gunters.

2. In Direct Proportionality, the Extent or Diſtance from the firſt Term to the ſecond Term; is the ſame as the Extent or Diſtance from the third Term to the fourth Term.

3. In Multiplication, the firſt Term is Unity; and in Diviſion, either the ſecond or third Term is Unity.

4. Powers are raiſed by doubling, or trebling, &c. the diſtances from Unity. Roots are extracted by halfing, thirding, &c. the diſtances from the Powers.

5. In the Sliding Gunter's, the Slider ſupplies the uſe of the Compaſſes, by the correſpondent numbers oppoſite to each other; therefore the ſame Rules hold for one as the other.

6. The Sliding Gunter's Line of Numbers, is ſometimes thrown into the Circumference of a Circle by various methods.

## SECTION XXXVII.

### DIRECTIONS for uſing the Rectifier.

1. The Rectifier conſiſts of two Concentric Circles, each having in it's circumference the Degrees and correſpondent Points of the Compaſs-card.

2. The lowermoſt circle repreſents the true Horizon, and the upper-

moſt circle, the Compaſs-card pointing out the falſe North, falſe South, falſe Eaſt and falſe Weſt.

3. When the Sun's true Amplitude is found, it is ſet off from the true Eaſt or true Weſt on the Rectifier to the place of the Sun.

4. The falſe Amplitude is then ſet off from the place of the Sun to the falſe Eaſt or falſe Weſt.

5. The Difference between the true Eaſt and falſe Eaſt, or the true Weſt and falſe Weſt, or rather what they are apart from each other, which is ſometimes their Sum, is the Variation of the Compaſs.

## SECTION XXXVIII.

### DIRECTIONS for the Uſe of Variation Charts.

1. A Variation Chart hath three principal Lines belonging to it, namely, 1ſt. Lines of the parallels of Latitude. 2d. Meridians ſhewing the Longitudes of Places on the Chart. 3d. Lines of Variation, ſhewing the Variation of the Compaſs at thoſe places on the Chart where they paſs.

2. Where the Latitude and Longitude Lines meet, the Variation is ſhewn on the Chart.

3. Where the Latitude and Variation Lines meet, the Longitude is ſhewn on the Chart.

4. Where the Longitude and Variation Lines meet, the Latitude is ſhewn on the Chart.

5. When the Latitude and Longitude are known ſomewhat near the truth; by knowing the Variation, it is ſhewn when the Sun or any Celeſtial Body is either near the Meridian, or any other true Point of the Compaſs.

## SECTION XXXIX.

### DIRECTIONS for uſing the Croſs-ſtaff.

1. This Inſtrument conſiſts of two parts, a Staff ſeveral Feet in length, and another ſliding thereon, at right Angles, from one end toward the other.

2. The Obſerver having put on the Croſs or Slider, brings the End of the Staff to his Eye, whilſt his Sight is directed upward toward the Sun, by the upper End of the Croſs; and under, toward the Horizon by the lower End of the Croſs. Then, the Degrees on the Side of the Staff, ſhew the Altitude above the Horizon.

3. This Inſtrument has been long uſed, but it is now judged to be very imperfect.

## SECTION XL.

### Directions for the Uſe of Davis's Quadrant.

1. Davis's Quadrant hath two Arches, a greater and a leſs; alſo, a Horizon Vane and two Sight Vanes.

2. The Horizon Vane is at the Centre. The Shade Vane is on the upper or leſſer Arch. The Sight Vane is on the lower or greater Arch.

3. In obſerving with the Inſtrument, the obſerver turns his back to the Sun, and looking through the Eye-hole in the Sight Vane, ſees the Horizon and either the Image or Shade from the Sun, united in the Horizon Vane.

4. The Sum of the Degrees and Minutes on both the Arches, between the Sight Vane and Shade Vane, is the Altitude required.

5. This Inſtrument is now uſed by foreigners and many Engliſh Mariners.

## SECTION XLI.

### Directions for uſing the Aſtrolabe.

1. This Inſtrument is held freely by its Ring, and its Index is put ſo that the Image of the Sun may paſs from the upper to the lower part thereof, diametrically.

2. The Degrees and Minutes from the Horizontal Line, to either the upper or lower part of the Index (that which is neareſt) is the Altitude required.

3. This Inſtrument has been by ſome, much approved of, but is now thought of little uſe.

## SECTION XLII.

### Directions for keeping a Sea Journal.

1. A Sea Journal is the principal Book for ſhewing the place of the Ship, and what places ſhe hath been at during a Voyage, with an Account of what has happened.

2. At Sea, the Day is ſuppoſed to begin at Noon, and to be reckoned on 12 Hours to Midnight, and 12 Hours more to the next day at Noon; 24 Hours in all.

3. To be correct, every Courſe ſhould be cleared from Lee-way and Variation; but when ſeveral Courſes are nearly alike, the Medium of them may be taken, and that cleared, to get the true Courſe.

4. When Eight Fathoms of the Log-line make one Knot, it will not be ſo eaſy to ſum up the Diſtances ſailed, as when Ten Fathoms make a Knot; becauſe the latter agrees with the common ſcale of Whole Numbers.

5. Every Day at Noon the Journal is to ſhew the following particulars, namely. 1ſt The Courſe made good during the laſt 24 Hours. 2d The Diſtance made good. 3d The Difference of Latitude, Northing or Southing. 4th The Departure Eaſting or Weſting. 5th The Meridian Diſtance, which is the Departure made good in Degrees and Minutes, from the laſt Land, the Ship departed from ; reckoning 60 Miles of Departure to a Degree. This is but of little uſe in the Journal. 6th The Latitude in by Account. 7th The Difference of Longitude made. 8th The Longitude in. 9th The Bearing and Diſtance of the Land the Ship took her Departure from.

## SECTION XLIII.

## DIRECTIONS for uſing the Terreſtrial Globe.

### 1 To find the Diſtance of any two places.

Meaſure it with the Quadrant of Altitude or a Pair of Compaſſes, and each Degree of Diſtance is 60 Nautical Miles or 69½ Engliſh Miles.

### 2. To find the Latitude of a place.

Bring the place to the Braſs Meridian, and the Latitude, North or South, is the Diſtance from the Equinoctial, in Degrees and Minutes.

### 3. To find the Longitude of a place.

Bring the place to the Braſs Meridian, and the Longitude Eaſt or Weſt, is the Diſtance from the Meridian of London, in Degrees and Minutes ; counting on the Equinoctial.

### 4. To find thoſe places of the Earth, where the Sun is Vertical at Noon, on any given Day.

Find how much the Sun is Northward or Southward of the Equinoctial at Noon by the Scale of Declination for that purpoſe, or by his place in the Ecliptic ; and all the places in that Circle and at that Diſtance from the Equinoctial, are thoſe required.

### 5. To find where the ſun is Vertical, at a given Hour of a given Day.

Find at what Diſtance the Sun is from the Equinoctial, North or South thereof by the former problem. Then reckoning 15 Degrees to an Hour of Time ; count as many Hours to the Eaſtwaad or Weſtward, on the Equinoctial, as is the given Hour, and in that Meridian at the forementioned Diſtance North or South of the Equinoctial, is the place required.

### 6. To ſhew the illuminated and unilluminated Hemiſphere, for a given time.

Find where the Sun is Vertical ; and 90 Degrees therefrom, all round, is the Great Circle, ſeparating the illuminated and unilluminated Hemiſpheres. The Places reſpectively, are as many Degrees above the Horizon of the Globe, as the Sun is at that time elevated above the Horizon at thoſe places.

7. To find on what Point of the Horizon, one place bears from another place that is given.

Bring the given place uppermoſt (which is done by turning it to the Braſs Meridian and elevating the Pole to the Latitude of the place). Then the Quadrant of Altitude being laid from the given place and paſſing over the other place, ſheweth the Degrees on the Horizon which is the Bearing required.

8. The Bearings of places are not from each other on Oppoſite Points of the Compaſs, unleſs they are in the ſame Meridian; or in the Equinoctial Line.

9. The Bearings of places are the Angles of a Spherical Triangle, and the Diſtances are the Sides.

## SECTION XLIV.

### DIRECTIONS for uſing the Celeſtial Globe.

1. To ſet the Celeſtial Globe to the Latitude of a place.

Elevate the Pole of the Globe, as many Degrees and Minutes above the Horizon, as i[illegible] Latitude of the place; the North Pole for North Latitude, and South Pole for South Latitude; and it is the Elevation required.

2. To ſet the Globe [illegible]he Latitude of a place and to the Sun's Place in the Eclipt[illegible] ſolve the Problems depending on theſe adjuſtments.

Elevate the Globe to the Latitude of the place; and having found the Sun's Place in the Ecliptic for the given Day, bring it to the Braſs Meridian, and turn the Hour Index to 12.

The Globe being thus adjuſted, will ſolve theſe following Problems, without any other adjuſtment.

1ſt. Turn the Sun 18 Degrees under the Eaſtern Horizon, and the Hour Index ſhews the time of the Beginning of Twilight.

2d. Turn the Sun to the Eaſtern Horizon, and the Hour Index ſhews the time of Sun Riſing.

3d. At the ſame time the true Amplitude of Sun-Riſing is ſhewn on the Horizon.

4th. The Sun being over the Eaſt Point of the Horizon; the Hour Index ſhews when the Sun is due Eaſt; and his Height or Altitude at that time may be meaſured.

5th. Turn the Hour Index to 6 Hours Eaſtward; and the Altitude at that time may be meaſured; alſo, by dropping a Perpendicular on the Horizon, his Azimuth from the North or South Point of the Horizon at that time.

6th. Turn the Globe to any other Hour, ſo that the Sun is ſhort of the Meridian; and his Altitude, alſo his Azimuth, is ſhewn in the ſame manner.

7th. If it be turned to a given Altitude, the Hour and Azimuth are ſhewn.

8th. If it be turned to a given Azimuth, the Hour and Altitude are ſhewn.

9th. Turn the Sun to the Braſs Meridian, and his Meridian Altitude is ſhewn. Alſo, his Declination North or South of the Equator. Alſo, the fixed Stars that are above the Horizon at Noon, in their reſpective ſituations, altitudes, azimuths, &c.

10th. The Stars then on the Eaſt-ſide of the Meridian are increaſing in Altitude, but thoſe on the Weſt ſide are decreaſing.

11th. Turn the Sun to the Weſtward of the Meridian, and the ſame Problems may be ſolved for the Afternoon.

12th. Turn the Sun any where below the Horizon, and all the Problems ariſing from the Situations of the Fixed Stars are eaſily ſolved by inſpection.

3. The Places of the Moon and Primary Planets being found either in or near the Ecliptic, the ſame Problems may be ſolved concerning them as for the Fixed Stars.

4. The Circumpolar Stars that do not ſet in the given Latitude; have two Meridian Altitudes; one below and the other above the Pole.

5. The Stars that never ſet, have their Polar Diſtances, not exceeding the Latitude of the place; except, a ſmall addition ariſing from the effect of Refraction.

6. The Stars which have not a greater Diſtance from the oppoſite Pole than the Latitude of the place, do not appear in that Latitude, except with a very ſmall Altitude, occaſioned by Refraction.

7. The Degree or Point of the Equator on the Meridian with the Sun, is his Right Aſcenſion. The Point of the Ecliptic is his Longitude.

8. The Degree or Point of the Equator Riſing with the Sun is his Oblique Aſcenſion. That ſetting with the Sun is the Oblique Deſcenſion.

9. The Difference between the Right and Oblique Aſcenſion, is the Aſcenſional Difference, or Difference between the time of Sun Riſing and 6 o'clock.

10. Like Solutions ariſe concerning the Fixed Stars, the Planets, and the Moon; except, that they have Latitude North or South, perpendicularly to the Ecliptic, and that a ſmall difference ariſeth from the Moon's Horizontal Parallax at her Riſing and Setting, and different Degrees of Altitude.

11. Medium Cœli, is the point of the Ecliptic on the Meridian.

12. The Angle made with the Meridian and Ecliptic, is continually changing.

## SECTION XLV.

### DIRECTIONS for Projecting the Sphere on the Plane of the Meridian Stereographically.

1. One Diameter repreſents Half of the Equator and that at Right-angles thereto, the Six o'Clock Hour Circle.

2. All other Meridians are Arches of Circles, ſet off with the Semi-tangent of their Diſtances reſpectively from the Six o'clock Hour-circle, and drawn through the Poles.

3. A Tangent at that diſtance ſets them off from the Centre of the Circle; and a Secant of the ſame draws them.

4. For leſſer Circles, parallel to the Equator, a Semi-tangent ſets them off from the Centre; and a Chord at the Circumference.

## SECTION XLVI.

### DIRECTIONS for Projecting the Sphere on the Plane of the Meridian Orthographically.

1. The Diameters drawn at Right Angles to each other, are the ſame as in the Stereographic Projection.

2. The Meridians are Ellipſes; the leſſer Circles parallel to the Equator, are ſtraight Lines, meeting the Chords in the Arches.

3. All great Circles paſſing through the Centre, are ſtraight Lines.

4. This Projection (likewiſe the Stereographic Projection) is applicable for the Solution of Spherical Problems by Inſpection.

## SECTION XLVII.

### DIRECTIONS for computing Great Circle Sailing.

1. In a Right-angled Spherical Triangle, the Baſe and Perpendicular, the Complement of the Hypothenuſe, and the Complement of the two adjoining Angles, are the five Circular Parts.

2. The Sine of a Middle Part together with Radius, makes the Tangents of the next adjoining parts, and the Coſines of the Parts not next adjoining.

3. In any Spherical Triangle; the Sines of the Sides, are directly as the Sines of the oppoſite Angles.

4. As the Tangent of the Half Baſe, is to the Tangent of the Half-Sum of the Sides; ſo is the Tangent of the Half Difference of the Sides, to the Tangents of the Half Difference of the Segments of the Baſe.

5. The Difference of Longitude of two places, is an Angle at one of the Earth's Poles,

6. The Diſtance of two places in the arch of a Great Circle, is one Side of a Spherical Triangle; and the other two Sides, are the Co-lati-

Co latitudes of the places ſailed from and to.

7. When Great Circle Sailing is applied duely North and South, the ſhip ſails on a Meridian; but at the Equinoctial it ſails along the Equinoctial Line.

8. At other Places and under other Courſes, it cuts the Meridians under different Angles, and alters the Courſe at every part of the Track.

## SECTION XLVIII.

### Directions for finding the Diſtance of one Place from another by the Motion of Sound.

1. By Experiments, Sound moves in the open air 1200 Engliſh feet, or 400 Yards in a Second of time.

2. When it ſtrikes againſt Objects at near Diſtances and is reflected from them, it moves 1140 Engliſh feet or 380 Yards in a Second of time.

3. Multiply the number of Seconds it is in motion, by the Diſtance it goes in a Second the Product is the Diſtance.

4. Divide the Diſtance by its motion per Second, and the Quotient is the time of it's flight.

5. A Pendulum $39\frac{2}{10}$ Inches; alſo a Pocket-watch will give the Interval of time.

6. The Interval between the Appearance of the Flaſh and hearing the Report of a Gun, is the time of its motion. So is that between ſeeing the Lightening and hearing its Thunder.

7. This method may be of uſe at Sea, and near the Coaſts; where great exactneſs is not wanted.

## SECTION XLIX.

### Directions for taking a Sketch of the Coaſt.

1. Diſtances may be taken ſomewhat near the truth by the Motion of Sound.

2. Angles may be taken either by the Sextant or by the Octant.

3. Other Diſtances and Poſitions my be inferred from the properties of Plane Triangles.

4. Intermediate Objects may be drawn on the Spot, as they are ſuppoſed accurately to be, by their Appearance to the Eye.

5. Rocks above or under Water, Sands, Soundings, &c. may be laid down by this method, near the truth; where Accuracy cannoi be had.

SECTION

## SECTION L.

### DIRECTIONS for correcting the Errors in Spherical Computations, which ariſe from the Spheroidical Figure of the Earth.

1. In Spherical Computations, the Earth and Sea together are commonly ſuppoſed a perfect Sphere or Globe.

2. The true Figure of the Earth is that of a Spheroid, flattened toward the Poles.

3. Near the Latitude of 45° North or South, a Perpendicular to the Meridian deviates from a direction toward the Centre, near a third part of a Degree.

4. The horizontal Tangents in that Latitude under a North-eaſt and South-weſt Direction; alſo, under a North-weſt and South-eaſt Direction; are different from what they would be, if the Earth was a perfect Sphere.

4. The Spheroidical Horizon muſt be reduced to the Spherical one, before the Calculations depending thereon can agree with thoſe of Spherical Triangles.

6. The Computations for Time at the Ship; alſo, for the true Azimuth, require this Correction.

7. When Obſervations are made near the due Eaſt or Weſt points of the Horizon, this error may in a great meaſure be avoided.

8. When Obſervations are made near the Meridian the ſame Advantages follow; but then there is frequently a great diſadvantage on account of the ſlow advance in Altitude of the Sun or Stars.

## SECTION LI.

### DIRECTIONS concerning Logarithms.

1. Index 10. with Cyphers, is the Logarithm of Radius. Index 20. with Cyphers, is the double Logarithm of Radius.

2. Subtract the logarithmic Sine from the double Logarithm of Radius; remains the logarithmic Co-ſecant.

3. Subtract the logarihtmic Tangent from the double Logarithm of Radius; remains the logarithmic Co-tangent.

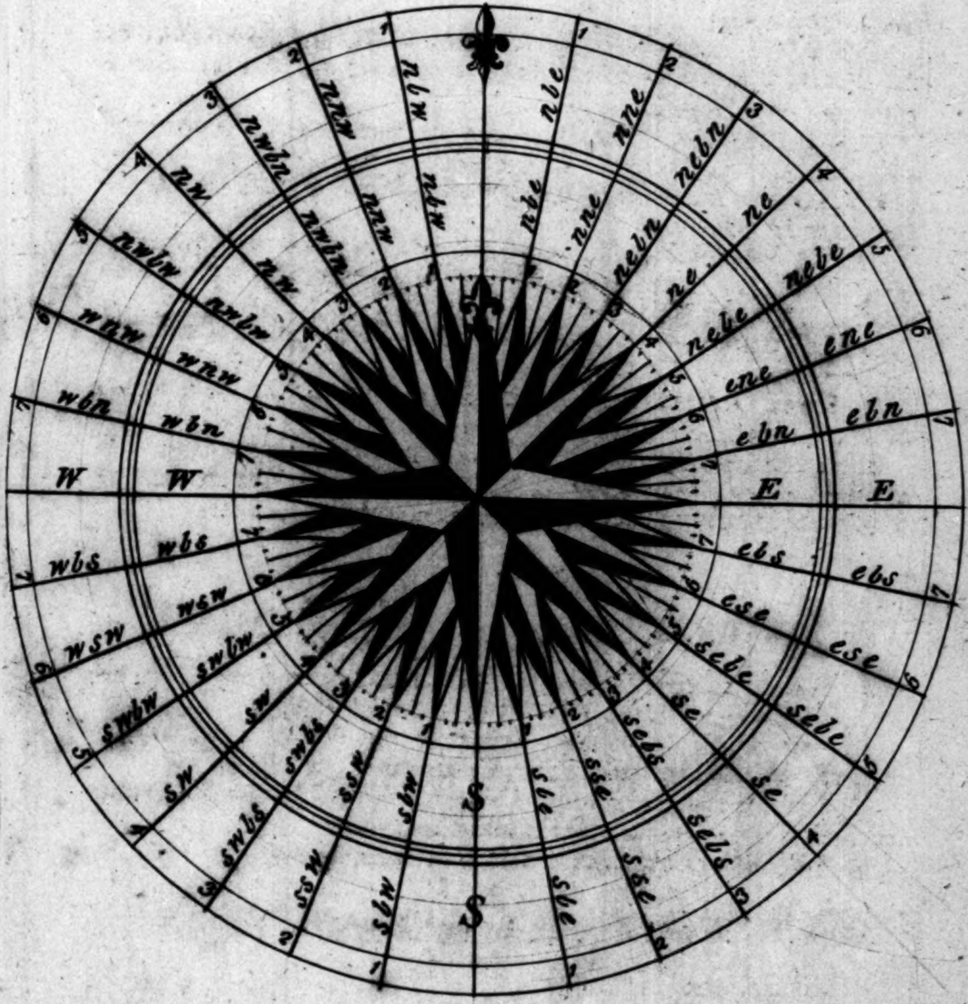
4. The Sine of an Arch is that of its Supplement.

360 Propoſitions and Inſtitutes.

12th July, 1781. S. DUNN.

THE END.

# *An Improved Compass Card & Rectifier.*



*N.B. The Degrees are shewn by the Table.*

*The innermost Points being cut round & taken out & the other pasted on a Card, & both Parts being made concentrical by a thread, the Rectifier is made.*

S. Dunn delin.t

Published according to Act of Parliament Nov.r 17.th 1777. by S. Dunn.

# The Points & Degrees of the Compass Card.

| North | South | Points | D | M | North | South |
|---|---|---|---|---|---|---|
| | | | 2 | 49 | | |
| | | | 5 | 37 | | |
| | | | 8 | 26 | | |
| N. by E. | S. by E. | 1 | 11 | 15 | N. by W. | S. by W. |
| | | | 14 | 4 | | |
| | | | 16 | 52 | | |
| | | | 19 | 41 | | |
| N.N.E. | S.S.E. | 2 | 22 | 30 | N.N.W. | S.S.W. |
| | | | 25 | 19 | | |
| | | | 28 | 7 | | |
| | | | 30 | 56 | | |
| N.E.bN. | S.E.bS | 3 | 33 | 45 | N.W.bN. | S.W.bS. |
| | | | 36 | 34 | | |
| | | | 39 | 22 | | |
| | | | 42 | 11 | | |
| N. East | S. East | 4 | 45 | 0 | N. West | S. West |
| | | | 47 | 49 | | |
| | | | 50 | 37 | | |
| | | | 53 | 26 | | |
| N.E.bE. | S.E.bE. | 5 | 56 | 15 | N.W.bW. | S.W.bW |
| | | | 59 | 4 | | |
| | | | 61 | 52 | | |
| | | | 64 | 41 | | |
| E.N.E. | E.S.E. | 6 | 67 | 30 | W.N.W. | W.S.W |
| | | | 70 | 19 | | |
| | | | 73 | 7 | | |
| | | | 75 | 56 | | |
| E. by N. | E. by S. | 7 | 78 | 45 | W. by N. | W. by S. |
| | | | 81 | 34 | | |
| | | | 84 | 22 | | |
| | | | 87 | 11 | | |
| East. | East. | 8 | 90 | 0 | West. | West. |

S. Dunn delin.

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# F O R M S.

## For Time and Azimuths at Sea.

### For Hour Angles à Noon.

Co. lat. 38°. 29′ — 0 .2060
à Pole 72 . 32 — 0 .0205
Co. alt. 57 . 21
2) 168 . 22
½ Sum 84 . 11 ...... 9 .9978
Rem.r 26 .50 ...... 9 .6546
2) 19 .8789
29°. 34′ 9 .9394
2
15) 59 .8 (3h. 56′. 32″

Co. lat. 38°. 29′ — 0 .2060
à Pole 112 . 21 — 0 .0339
Co. alt. 87 . 32
2) 238 . 22
½ Sum 119 . 11 ...... 9 .9410
Rem.r 31 . 39 ...... 9 .7199
2) 19 .9008
26°. 52′ 9 .9504
2
15) 53 . 44 (3h. 34′. 56″

### For Azimuth Angles.

Co. lat. 38°. 29′ — 0 . 2060
Co. alt. 57 . 21 — 0 . 0747
à Pole 72 . 32
2) 168 . 22
½ Sum 84 . 11 ...... 9 . 9978
Rem.r 11 . 39 ...... 9 . 3052
2) 19 . 5837
38°. 15 9 . 7918
2
76 . 30 Azimuth

Co. lat. 38°. 29′ — 0 . 2060
Co. alt. 87 . 32 — 0 . 0004
a Pole 112 . 21
2) 238 . 22
½ Sum 119 . 11 ...... 9 . 9410
Rem.r 6 . 50 ...... 9 . 0754
2) 19 . 2228
65°. 52 9 . 6114
2
131 44 Azimuth

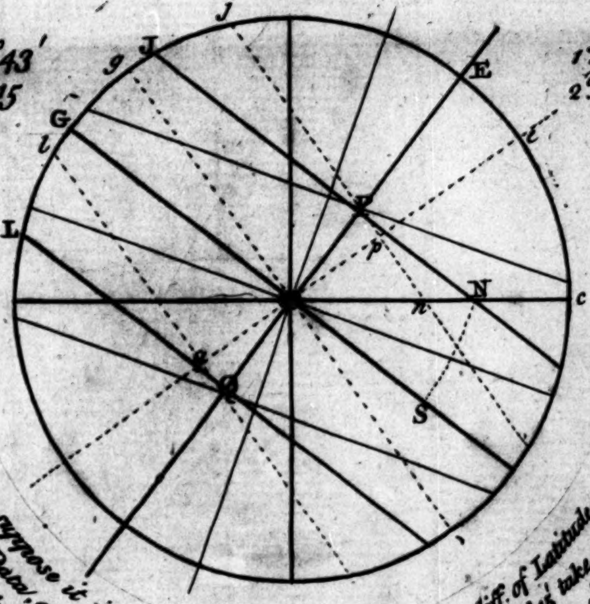
For the Preparation and Corrections,
See the Precepts at large.

S. Dunn delin.t

Published according to Act of Parliament Nov.r 17.th 1777. by S. Dunn.

**Data.**
Polar dist. 78°.43'
Elap. time 21.15

**Data.**
1.st Co alt. 43°.5'
2.d Co alt. 35.53



Aſſume the Latitude twice, as suppose it is 46°.20' or 46°.36', with which & the Data, get the two hour Angles, & the false elapsed times will be 20°.34' & 21°.42', the diff. is 68' & the diff. of Latitude 16'. From the true elapsed time 21°.15' take 20°.34' remains 41'. As 68 to 16'; so 41' to 10'; which added to 46°.20' gives 46°.30' the true Latitude of the Place required.

## Calculation.

Lat. 46 . 20
Co. lat. 43 . 40 Co. ar. 0 . 16086
à Pole 78 . 43 Co. ar. 0 . 00848
Co. alt 43 . 5
2) 165 . 28
82 . 44 Sine 9 . 99650
39 . 39 Sine 9 . 80489
2) 19 . 97073
14 . 47 ------ 9 . 98536
∠ 29 . 34 ---------- is 20°.34' Diff.

Lat. 46 . 20
Co. lat. 43 . 40 Co. ar. 0 . 16086
à Pole 78 . 43 Co. ar 0 . 00848
Co. alt. 35 . 53
2) 158 . 16
79 . 8 Sine 9 . 99214
43 . 15 Sine 9 . 83581
2) 19 . 99729
4 . 30 ------ 9 . 99864
∠ 9 . 0

Lat. 46 . 36
Co. lat. 43 . 24 Co. ar. 0 . 16299
à Pole 78 . 43 Co. ar. 0 . 00848
Co. alt 43 . 5
2) 165 . 12
82 . 36 Sine 9 . 99637
39 . 31 Sine 9 . 80366
2) 19 . 97150
14 . 36 ------ 9 . 98575
∠ 29 . 12 ---------- is 21°.42' Diff.

Lat. 46 . 36
Co. lat. 43 . 24 Co. ar 0 . 16299
à Pole 78 . 43 Co. ar 0 . 00848
Co. alt 35 . 53
2) 158 . 0
79 . 0 Sine 9 . 99195
43 . 7 Sine 9 . 83473
2) 19 . 99815
3 . 45 ------ 9 . 99907
∠ 7 . 30

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